

# PATENT SPECIFICATION

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## (54) HOT RUNNER

(71) We, ROHM AND HAAS (UK) LIMITED, a British Company, of Lennig House, 2 Mason's Avenue, Croydon, CR9 3NB, do hereby declare the invention for which we pray that a patent may be granted to us, and the method by which it is to be performed to be particularly described in and by the following statement:—

The invention is concerned with heated runner manifolds, which are devices for transferring molten plastics material from an injection moulding machine to a mould.

Traditionally moulds are filled via a sprue bush and runner system machined into the mould cavity retaining plate. The contents of the sprue and runner system cool with the moulded component or components and are ejected from the mould together with the moulded parts.

This then requires that for economy the contents of the runner system be removed from the component and re-used, usually after granulation. Such re-granulated powder is liable to be contaminated and may be blended with new material or otherwise treated, for example dry coloured, to reduce the effects of contamination.

The necessity for this reclamation system is an obvious economic disadvantage.

To overcome this disadvantage, a "hot runner" system has been used wherein the manifold comprises accurately machined channels, usually of semi-circular cross-section, on the facing surfaces of heated metal blocks which are held together to form complete channels, usually of circular cross-section. Molten plastics material, i.e. the melt, is supplied from an injection moulding machine through a nozzle which is seated into a recess in the rear face of the composite metal block. The melt then passes via an inlet tube in the block through the channels which distribute the melt to nozzles, seated into a mould plate and thence to the mould cavities where it is cooled and solidifies. This heated mass of metal in the block has the advantage of minimising the temperature gradient between the injection moulding machine nozzle and the nozzles of the manifold. It also serves as a

heat sink which may absorb excess heat from or supply heat to the plastics material. However such manifolds are expensive to produce, slow to reach operating temperature and slow to respond when a rapid alteration of the temperature is required. The temperature of such a manifold is difficult to control, particularly at the manifold nozzles where accurate heat control is essential to obtain a balanced flow of plastics material. It is difficult to synchronise the moulding cycle with the heat supply or demand of the metal block since additional heat is intermittently provided by the melt which the heaters cannot anticipate. Due to the heat capacity of the metal block the temperature of the manifold cannot be altered sufficiently quickly to accommodate a temperature fluctuation. This fluctuation affects the temperature of the manifold nozzles where the plastics material may vary from slightly drooling to almost frozen off. The deliberate formation of an insulating wafer of plastics between the manifold nozzle seatings, which are located in the mould plate, and the nozzles reduces this problem but stoppages during the operation of the moulding machine still frequently occur.

Heat lost via the manifold nozzles to the mould plate has to be made up by the nozzle heaters. The consequential demand on these heaters may be so high that the heaters are overloaded, frequently burn out and require replacement.

It is not practical to increase the temperature of the manifold block to reduce the loading on the nozzle heaters, as the plastics in the melt channel would then be locally subjected to excessive temperatures and thus could be degraded and discoloured.

Despite the apparent drawbacks the heated block design has been persevered with because the advantages offered by the presence of the large mass of metal have been considered to outweigh the disadvantages.

We have now found a hot runner manifold of special construction which avoids the use of this large mass of metal previously required.

According to the invention there is pro-

vided a tubular hot runner manifold having runners which comprise a plurality of tubular arms which radiate from a common joint, said arms having a swan-neck configuration as hereinafter defined.

In manifolds of the invention the runners may conveniently comprise tubular arms radiating from a common joint at one end of an inlet, which may itself be tubular. At the other end of the inlet there may be a seating for the nozzle of an injection moulding machine. Manifolds of the invention are for location between the mould support plate, into which the mould machine nozzle is to be seated, and the mould plate, into which the manifold nozzles are to be seated.

The manifold of the invention should be so arranged, located, or designed to withstand, in use, pressure exerted upon them between the moulding machine and the mould plate. Such pressure is conventionally used to grip runner blocks in position with the various nozzles securely located in their seatings. In one preferred embodiment of the invention the manifold is provided with means for attaching or mounting it upon the mould plate so that the load from the moulding machine nozzle is borne by the mould support plate. This may also overcome, in use, any tendency for the manifold nozzles to be pushed out of their seatings in the mould plate by internal pressure of the plastics material in the runner tubes.

The swan-neck configuration of the manifolds of the invention minimises or prevents deformation due to thermal expansion as they are heated from ambient temperature to operating temperature.

Additional means to minimise or prevent such deformation may be provided. For example, the inlet may be so designed as to be slidably located for fixing subsequent to heating to operating temperature. The manifold may be provided with an inlet which, in use, projects through an orifice in the mould support plate so that the injection moulding machine nozzle seating is located on the opposite side of the plate from the remainder of the manifold. On heating the manifold can then expand in the direction of the gripping pressure described above through the orifice until operating temperature is reached and means may be provided to take up the thermal expansion of the manifold and to fix it rigidly between the mould support and mould plates.

For example, the injection moulding machine nozzle sealing may be provided with an external thread in order to accept a nut which may be brought to bear against the mould support plate.

The manifolds of the invention are so designed that expansion of the manifold occurs in a direction perpendicular to the line of the gripping pressure. This is achieved by

the tubular arms, i.e. the runners, having a "swan neck" configuration. By "swan neck" is meant that an arm is bent so that its longitudinal axis at one end is substantially perpendicular to, and in a plane parallel to, said axis at the other end. A manifold having this design may be rigidly attached to both the mould and mould support plates.

The number of tubular arms in the manifolds of the invention is not critical, but may conveniently range from two to eight.

The manifold nozzles are preferably provided with means for accurate local temperature control.

Conventional nozzles have been heated by surrounding them with bands or cartridge heaters, the latter being recessed into the external wall of the nozzles, and their temperature monitored by thermocouples set as close as possible to the channel through which the molten plastics material passes. The size of the nozzle limits the size of band heater which may be used and such heaters are frequently found to have an inadequate heat supply capability for reliable operation. Cartridge heaters are also liable to failure, particularly at the joints between the heater and cable leads.

For example, the manifold nozzles may be provided with heaters which comprise a mineral-insulated heating element wound round the nozzle in the form of a coil. Such heaters may also be used in other parts of the manifold, particularly around the inlet, where it is required to maintain the plastics material at the operating temperature.

It is important that heat transfer from the manifold to the mould plate be minimised. Loss of heat from the manifold by this means necessitates increased operating temperature, thereby increasing the possibility of thermal degradation of the plastics material. Heat transfer to the mould plate also necessitates an increase in the efficiency with which the plastics material is cooled in the mould cavities.

The manifolds of the invention may be provided with means for attaching the manifold nozzles to the mould plate and/or providing insulation between the nozzles and the mould plate.

The manifold nozzles may be attached to the mould plate by means of shrouds, for example tubular shrouds, for transmitting clamping pressure to the nozzles through a flange around the nozzle which may be positioned behind the nozzle heater. The shroud may enclose the nozzle and its heater and provide an air-gap between the nozzle and the shroud.

The manifold inlet may also be provided with a heater around its external wall and preferably has a shroud encompassing the inlet in order to provide an air-gap between the heater and the shroud.

More preferably the manifold, in use, may

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be provided with insulating lagging between the shroud around the inlet and the mould support plate to minimise heat transfer from the shroud to the plate.

5 The lead ends of each nozzle of the manifolds of the invention and the nozzle seatings in the mould plate may be so shaped as to allow the nozzles, in use, to become encapsulated by a plastics wafer. This provides further  
10 insulation between a nozzle and the mould plate by using the relatively poor thermal conductivity of the plastics material. The thickness of the plastics wafer is not critical but must be such that it is readily burst by  
15 the flow of plastics material when it is desired to fill a mould cavity.

Operating temperatures are also affected by the internal diameter of a manifold nozzle outlet. An increase in this diameter tends to  
20 reduce the required operating temperature and is therefore beneficial since a lower melt temperature decreases the possibility of thermal degradation of the plastics material.

Optimum balance of wafer thickness and  
25 internal diameter of nozzle outlet will be dependant on flow characteristics of the plastic material and its melt transition temperature.

To gain maximum advantage of the facility  
30 for rapid temperature changes of the tubular manifold, it has been found advantageous to use instruments of the solid state type with thyristor control. By this means, nozzle temperatures can be maintained to within  
35  $\pm$  or  $-1^{\circ}\text{C}$ . of the set point.

It is also desirable to use separate instruments for each nozzle so that any slight imbalance can be compensated on individual  
40 nozzles. Thermocouple location is advantageously near the nozzle tip. The remainder of the manifold is usually run at a slightly lower temperature than the nozzles and may also be controlled by a solid state instrument. The thermocouple is preferably located near the  
45 junction of the inlet tube with the outlet tubes.

Some embodiments of the manifolds of the invention will now be more particularly described by reference to the accompanying drawings.

50 Fig. 1 is a sectional view of a manifold of the invention;

Fig. 2 is a plan view of a further manifold of the invention;

55 Fig. 3 is a sectional view of a third manifold of the invention;

Fig. 4 is a plan view of a fourth manifold of the invention.

Referring to Fig. 1, the manifold comprises an inlet tube (101) having, at its inlet  
60 end (102), a throat (103) which forms a moulding machine nozzle seating (104). At the throat (103) there is an externally threaded flange (105) for engaging a nut (106) to take up thermal expansion in the manifold. This nut (106) may, in use, be

tightened against a mould support plate (107) of a moulding machine (not shown). The inlet tube (101) is heatable by an external coil heater (108).

At the delivery end of the tube (101) is a "T" junction (109) with two outlet tubes  
70 (110). The outlet tubes are of similar length and curvature in a swan neck configuration and each terminates in a nozzle (111 and 111a).  
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The nozzles are heatable by external coil heaters (112 and 112a) and each nozzle has a circular flange (113 and 113a) located within a tubular shroud (114 and 114a) so that the shroud may grip the flange, thereby  
80 in use attaching the nozzles to the mould plate (not shown).

Fig. 2, depicts a manifold of the same design as that of Fig. 1 except that the manifold of Fig. 2 has four arms (202) rather than  
85 two. The junction (201) of these arms thus has a substantially square plan. Each arm terminates in a nozzle (203) each of which are externally heatable by coil heaters (not shown) and have a circular flange (204). This  
90 flange is located within a flanged ring by which the nozzles may be attached to a mould plate (not shown).

Fig. 3 depicts a manifold according to the invention having an inlet tube (301) with  
95 a throat (302) forming a moulding machine nozzle seating (303). The inlet tube is externally heatable by coil heaters (304). The support plate (305) of a mould (not shown) is complementarily abutted to the inlet tube  
100 and is separated from a flanged cylinder (306) by an insulating split ring (307) recessed into the wall of the inlet tube. The flanged cylinder (306) defines an insulating  
105 air-gap (308) between its internal wall and the inlet tube. At its delivery the inlet tube has a junction (309) which has two outlets arranged in a plane perpendicular to that of the inlet tube axis, and from each outlet  
110 extends an outlet tube. The outlet tubes (310 and 310a) are of similar length and are curved similarly in a "swan neck" configuration and terminate in nozzles (311 and 311a). Each  
115 nozzle has external coil heaters (312 and 312a) and has an internally grooved flange (313 and 313a). Within this flange is seated a tubular shroud (314 and 314a) so as to form an insulating air-gap (315 and 315a). The  
120 nozzles are locatable in a mould plate (not shown) by lugs (316 and 316a). The outlet tubes of the manifold in Fig. 3, when viewed from the nozzle tips curve in a clockwise direction.

Fig. 4 depicts a manifold of the same design as that of Fig. 3 except that the manifold of Fig. 4 has four arms (402) rather  
125 than two and the arms, when viewed from the nozzle tips, curve in an anti-clockwise direction. The junction (401) of these arms thus has a substantially square plan. Each arm

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terminates in a nozzle (403) each of which are externally heatable by coil heaters (not shown) and have a circular, internally-grooved flange (404). Within this flange is located a tubular shroud (405).

#### WHAT WE CLAIM IS:—

1. A tubular hot runner manifold having runners which comprise a plurality of tubular arms which radiate from a common joint, said arms having a swan-neck configuration as hereinbefore defined.

2. A manifold as claimed in Claim 1 in which the common joint is located at one end of an inlet which has, at its other end, a seating for the nozzle of an injection moulding machine.

3. A manifold as claimed in claim 1 or 2 in which the end of each arm, remote from the common joint, has a nozzle.

4. A manifold as claimed in any preceding claim which has means for attaching or mounting it upon a mould plate to transfer, in use, the load from the moulding machine nozzle to a mould support plate.

5. A manifold as claimed in any of claims 2 to 4 in which the inlet, in use, projects through an orifice in the mould support plate so that the injection moulding machine nozzle seating is located on the opposite side of the plate from the remainder of the manifold.

6. A manifold as claimed in Claim 5 in which the injection moulding machine nozzle seating has an external thread in order to accept a nut which, in use, may be brought to bear against the mould support plate.

7. A manifold as claimed in any preceding claim having from two to eight arms.

8. A manifold as claimed in any preceding claim in which the manifold nozzles have means for local temperature control.

9. A manifold as claimed in Claim 8 in which the manifold nozzles are provided with heaters.

10. A manifold as claimed in Claim 9 in

which each heater comprises a mineral-insulated heating element wound round the nozzle in the form of a coil.

11. A manifold as claimed in any preceding claim in which the inlet is provided with a heater, which comprises a mineral-insulated heating element wound round the inlet in the form of a coil.

12. A manifold as claimed in any preceding claim having means for attaching the manifold nozzles, in use, to the mould plate and/or providing insulation between the nozzles and the mould plate.

13. A manifold as claimed in Claim 12 in which each manifold nozzle is attached, in use, to the mould plate by means of shrouds which co-operate with flanges around the nozzles to transmit clamping pressure to the nozzles.

14. A manifold as claimed in Claim 13 in which the nozzle flanges are positioned behind the nozzle heaters so that the shrouds enclose the nozzles and their heaters and provide an air-gap between the nozzles and the shroud.

15. A manifold as claimed in Claim 11 in which the manifold inlet is encompassed by a shroud to provide an air-gap between the inlet heater and the shroud.

16. A manifold as claimed in Claim 15 which has insulating lagging between the shroud around the inlet and the mould support plate to minimise heat transfer, in use, from the shroud to the plate.

17. A manifold as claimed in Claim 1 substantially as described in any of the accompanying drawings.

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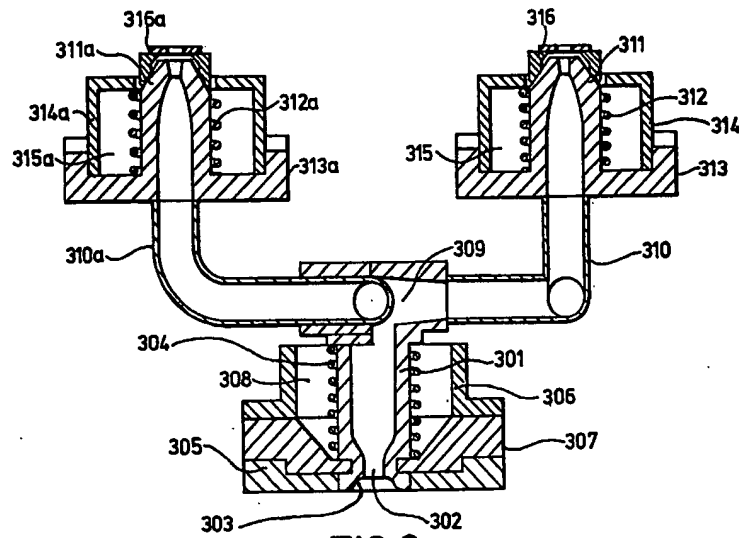


FIG. 3.

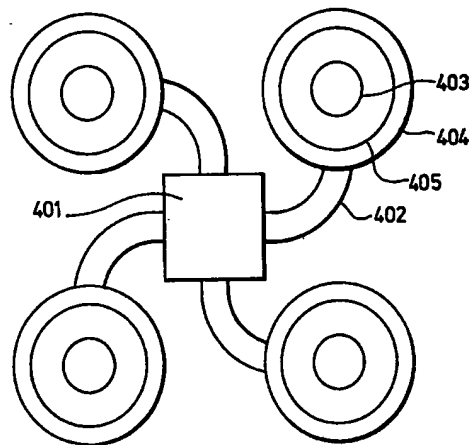


FIG. 4.